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FEASIBILITY OF REDUCING ABSORBENT CUSHIONING MATERIAL FOR OVERP--ETC(U)
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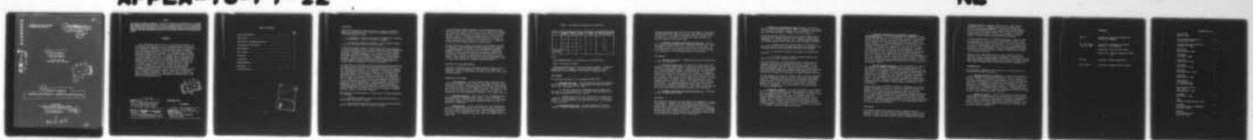

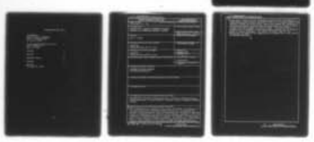

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6 FEASIBILITY OF REDUCING ABSORBENT CUSHIONING MATERIAL FOR OVERPACKING HAZARDOUS LIQUIDS

HQ AFALD/PTP
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NOTICE

ABSTRACT

This investigation was conducted at the request of HQ USAF. The objective of the investigation was to determine whether the quantity of noncombustible absorbent cushioning material used for overpacking unit containers of hazardous liquids can significantly be reduced from that presently specified in AFR 71-4, Preparation of Hazardous Materials for Military Air Shipment, by using plastic bags or liners inside the overpack containers. The plastic bag or liner would serve to confine liquids, in the event of leakage from unit containers, in overpack containers which are non-confining, such as fiberboard and unsealed wooden boxes. Results of this investigation indicate that the quantity of cushioning material presently specified in AFR 71-4 is probably based on that required to absorb the entire liquid content from leaking unit containers in non-confining overpack containers and can significantly be reduced by using overpack containers designed to confine liquids. For those overpack containers not so designed, closed plastic bags or liners offer an effective method to achieve confinement. The utility of plastic bags for this application will depend on the compatibility of plastics with a wide variety of hazardous materials.

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INTRODUCTION

Noncombustible absorbent cushioning material, hereafter referred to simply as cushioning material, serves two functions when used for overpacking hazardous liquids:

a. Absorption of liquids in the event of leaking unit containers, i.e., the containers in which the liquids are packaged.

b. Provide the necessary cushioning to prevent physical damage to the unit containers from shock and vibrations.

It would be desirable, though not commonly provided for in practice, to design the completed pack to prevent changes of position (migration) of the unit containers in relationship to the walls of the overpack container. Precluding migration, it is believed, may result in more predictable in-service performance, particularly in those instances where more than one unit container is overpacked in a single exterior container. However, packs designed to prevent migration were not included among the objectives addressed by this investigation, but perhaps should be considered for future investigation.

The quantities of cushioning materials, presently specified in AFR 71-4, are given in terms of the minimum thicknesses between the walls of the unit and overpack containers. These quantities are given for common unit container sizes of 1 pint to 30 gallons. It should be noted that the total weight or packing density (weight per unit volume) of the cushioning material is not specified. In practice, the cushioning material is poured into the overpack container with no attempt made to pack or compact the cushioning material other than that necessary to fill the voids around the unit containers and perhaps that achieved on closure by slightly overfilling the overpack container. This was the method used in this investigation. Packing densities achieved will approximate those achieved in determining the apparent densities of cushioning materials in which the material is poured into a container of known volume with no attempt made to settle or compact by tapping, vibratory action, or some other technique.

For purposes of this discussion, two basic types of overpack containers are considered:

a. Confining containers, sealed and constructed from materials which prevent the escape of liquids.

b. Non-confining containers, unsealed or constructed from porous materials which do not prevent the escape of liquids.

In non-confining overpack containers, the cushioning material must absorb the entire liquid content, in the event of sudden loss from the unit containers, before the liquid reaches the walls of the overpack container. This is essential to prevent escape of liquids from the overpack container. In confining overpack containers, on the other hand, the walls of the container provide barriers to the escape of liquids and absorption can continue to take place after liquids have reached the walls through capillary (wicking) action.

The test methods used in this investigation were designed to provide an indication of any significant differences between the quantities of cushioning materials required for non-confining and confining overpack containers. At the same time, if there is a significant difference, it was anticipated that the test methods would provide an indication of whether the quantities specified in AFR 71-4 are based on those required for non-confining or confining overpack containers. Closed plastic bags inside the overpack container were used to convert non-confining to confining overpack containers.

DESCRIPTION OF CUSHIONING MATERIAL

Vermiculite conforming to the requirements HH-I-585, Type II, Class 1, Insulation, Thermal (Vermiculite). This material is essentially equivalent to Size 2 of MIL-V-21628 specified in AFR 71-4. MIL-V-21628 has been cancelled.

DESCRIPTION OF TEST PACKS

1. Unit Containers. One quart, amber, necked, chemical bottles filled with one quart of water to which a small amount of blue, water-soluble dye was added to provide a visual indication of leakage through the overpack container. Bottle dimensions to a tolerance of $\pm$ 1/8 inch were 8 3/4 inches high by 3 1/2 inches in diameter. The volume occupied by the bottles in the overpack containers was 72 cubic inches, as determined by the water displacement technique to the nearest cubic inch.

2. Overpack Containers. Three sizes of V3c, RSC fiberboard boxes were employed with dimensions shown in Table I. The thicknesses of vermiculite between the bottles and overpack containers are also shown and compared against the thicknesses required by AFR 71-4, Table 1-1, using Size 2 vermiculite.

3. Completed Pack. A liner, fabricated from 4 mil polyethylene, with a wire closure, was used in one of the Size 3 boxes (see Table I) subjected to the bottle destruction test. Completed packs consisted of one quart bottles, overpacked with vermiculite, in fiberboard boxes. Outer flaps of the fiberboard boxes were closed with masking tape, two inches wide.

TABLE I - Box Dimensions/Quantities of Vermiculite

Box Size No.	Inside Dimension[1] (inches) Height	Width	Length	Quantity of Vermiculite[3] (inches) Sides	Top and Bottom
1	17.75	7.5	7.5	2	4.5
2	13.75	7.5	7.5	2	2.5
3	13.75	5.5	5.5	1	2.5
AFR 71-4[2] (minimum)	18.75	7.5	7.5	2	5.0

Notes:

[1]Box dimensions given to a tolerance of $\pm$ 0.125 (1/8) inch.

[2]Box of this size not tested.

[3]Thickness between walls of unit and overpack container. Vermiculite packing density for overpack containers ranged between 2.0 and 2.2 grams/cubic inch, determined to the nearest 0.1 gram/cubic inch.

TEST METHODS

All tests were conducted at room temperature (60°- 80°F).

1. Free fall drop tests. The following drop tests were conducted from a drop height of 60 inches, using apparatus described in Method 5007 of Fed. Test Method Std. No. 101B:

a. One drop on each face. Beginning with the largest pack (box size No. 1) and progressing to the smallest pack (box size No. 3), each pack was subjected to five drop cycles.

b. Repeated drops on one face. Three size No. 3 packs were assembled. One was subjected to 10 repeated drops on the bottom; the second, to 10 repeated drops on the top; and the third, to 10 repeated drops on one side.

2. Bottle destruction test. The bottle destruction test was intended to simulate catastrophic in-service destruction of the unit

container with sudden loss of the entire liquid content. Destruction was accomplished by a sharp blow to a 1/2 inch diameter rod inserted through a hole in one side of a completed overpack container. The side opposite to that with the hole was then turned down and the overpack container observed for leaks.

3. Vibration (repetitive shock)/free fall drop test. One size No.3 completed pack was subjected to repetitive shock for two hours in accordance with Method 5019 of Fed. Test Method Std. No. 101B. This was followed, first, by 10 repeated drops on the bottom and then by 10 repeated drops on one side, as described under the free fall drop test, paragraph 1.b of Test Methods section of this report.

TEST RESULTS

1. Free fall drop tests. No damage to the bottles resulted from the free fall drop tests.

2. Bottle destruction test. No leaks were observed through box sizes Nos. 1 and 2, neither of which contained a plastic liner. After two hours, the packs were opened. A small amount of water was absorbed by the inside fiberboard facings, as evidenced by the blue coloration, but none had penetrated through to the outer facings. The amount of vermiculite in these pack sizes appears to be sufficient to absorb the entire liquid content in the event of catastrophic destruction of the unit container. This was not the case with the box size No. 3 overpack container without the plastic insert. Water was observed to leak through the walls of the box within 5 to 10 seconds after destruction of the bottle. No leakage was observed, on the other hand, from the pack size No. 3 overpack containing the plastic insert. After two hours, the box was opened and inspected. This inspection revealed that the colored water had been completely absorbed by the vermiculite.

3. Vibration (repetitive shock)/free fall drop test. Inspection revealed no damage to the bottle.

DISCUSSION

This discussion, along with the test results, is intended to: provide the background leading to the Conclusions and Recommendations sections of this report; consider factors that might limit the utility of plastic bags or liners; and consider factors which could conceivably restrict the extent to which a reduction in the quantity of cushioning material used can be achieved in practice. In addition, basic methods of utilizing plastic bags or liners are discussed and the reason given for selecting the one employed in this investigation.

1. Methods of utilizing plastic bags or liners. Three basic methods of utilizing plastic bags or liners, for packaging and packing unit containers of hazardous liquids, will be considered. Only one of these, the first discussed, is commonly employed in practice.

In the first method, the unit container, in a closed plastic bag, is overpacked with cushioning material. This method is commonly used commercially for a wide variety of items. Restricting our discussion to hazardous liquids, plastic bags serve three conceivable functions:

a. To protect the unit container against contamination by dust particles from interior packaging materials, dirt and water. Such protection could be both cosmetically and practically desirable.

b. To confine the contents in the event of a leaking unit container.

c. To protect the unit container and labels against the abrasive action of the cushioning material.

In the second method of utilizing plastic bags or liners, the unit container, along with the cushioning material in a closed bag, is overpacked with cushioning material in the normal manner. In this method of employment, the unit container would "carry" some of its protection against damage as it migrates within the exterior container. This method may be of particular value in those applications where several unit containers are overpacked in a single exterior container.

The third method of utilization of plastic bags is the method employed in this investigation, with the function of the plastic bag already discussed. This method was chosen for the investigation as the most simple and direct in determining whether the amount of cushioning material can be reduced. It is felt, however, that the other two methods, or combinations of the three methods, merit consideration for future investigations.

2. Properties of plastic. It was not the intent of this investigation to consider potentially undesirable properties of plastics for use in packaging hazardous materials. Nevertheless, it should be noted that such properties may prohibit the use of plastic films with specific hazardous liquids or classes of hazardous liquids. As an example, plastic films exhibit the tendency to accumulate electric charges which, on discharge, may provide sufficient energy to ignite flammable liquids. Other potentially hazardous properties may have to be considered before plastic bags or liners are implemented for general use in hazardous liquids packaging applications.

3. Practical considerations in specifying the amount of cushioning material. In this investigation, the thickness of cushioning material was reduced to one inch between the sides of the smallest overpack box used and the sides of the unit container. Though test results indicate that this thickness is sufficient to protect a one quart container, it is probably undesirable to specify one inch as the minimum thickness required. The reason for this is that the unit container, in practice, will probably not be located in the exterior container with the same care used in this investigation. The more nearly the dimensions of the overpack container approach those of the unit container, the more significant will be a given displacement of the unit container from a symmetrical position within the overpack container. Restated, the more closely the thickness specified approaches the actual thickness required to protect the unit container, the more likely will displacement from a symmetrical position result in cushioning material thickness inadequate for protection on at least one side of the overpack container.

4. Unit and overpack containers. AFR 71-4 requires that either a unit container be capable of withstanding an internal pressure of approximately 13 psi and the effects of rapid decompression or that the unit container be overpacked in containers capable of withstanding these conditions. In the majority of overpack applications, then, plastic liners or bags are unnecessary since overpack containers conforming to this AFR 71-4 requirement would also serve as confining vessels for liquids. The most commonly used overpack containers are sealed metal drums. The utility of plastic bags or liners for these sealed overpack containers would be dictated by considerations not addressed in this investigation.

The majority of unit containers incapable of withstanding the internal pressure requirements of AFR 71-4, and which, therefore, require overpacking, are those with capacities under five gallons. Most unit containers with capacities of five gallons or more, authorized by AFR 71-4, are capable of withstanding the internal pressure requirements and are generally not required to be overpacked with absorbent cushioning material. The bulk of any cost savings to be realized by reducing the amount of absorbent cushioning material, from that presently specified in AFR 71-4, would consequently result from the reduced amount required for these smaller unit containers.

CONCLUSIONS

Test results indicate that the quantities of cushioning materials, specified in Table 1-1 of AFR 71-4, are significantly in excess of those required to protect the unit containers against damage from mechanical shock and to absorb the entire content of unit containers when overpack

containers designed to confine liquids are used. When overpack containers are not so designed, plastic bags or liners may be effective in achieving confinement. Test results further indicate that the quantities specified are probably based on those required to absorb the entire liquid content of unit containers before the liquid reaches the walls of the overpack containers, to prevent escape of liquids from non-confining overpack containers.

A cursory review of AFR 71-4 overpacking requirements indicates that, in the majority of cases, the use of plastic bags or liners is precluded because the overpack container serves to confine the liquid in the event of leakage from a unit container. The use of plastic bags or liners in these instances would be dictated by considerations not addressed by this investigation, such as the desirability of preventing contact of specific liquids or classes of liquids with the walls of the overpack containers.

Results of this investigation indicate that a cushioning material thickness of one inch on the sides was sufficient to protect a one quart unit container against damage. Nevertheless, the minimum required cushioning material thickness should be no less than two inches, regardless of unit container sizes (see Discussion section, paragraph 3).

RECOMMENDATIONS

The following recommendations are based on the Test Results and the Discussion section of this report.

1. Revision of Table 1-1 of AFR 71-4. It was not the intention of this investigation to provide data for the revision of Table 1-1 of AFR 71-4. Rather, as indicated in the abstract, it was intended as a preliminary investigation to determine whether the amount of cushioning material can be significantly reduced from the presently specified quantities. A subsequent investigation will be considered to determine the quantities of cushioning material required to overpack common unit container sizes in confining overpack containers. Consideration should be given to provisions for two different requirements, one for confining and one for non-confining overpack containers.

2. Hazards of plastics. Plastic bags and liners fabricated from polyethylene are the most suitable for the application under consideration because of cost effectiveness and the inertness of polyethylene to a wide variety of chemicals. Nevertheless, consideration should be given to some of the potential hazards associated with plastics. Among the most serious is the fire hazard from electrostatic discharge (see Discussion section, paragraph 2).

REFERENCES

AFR 71-4	Preparation of Hazardous Materials for Military Air Shipment
Fed. Test Method Std. No. 101B	Preservation, Packaging, and Packing Materials: Test Procedures Method 5007 - Drop Test (Free Fall) Method 5019 - Vibration (Repetitive Shock) Test
HH-I-585	Insulation, Thermal (Vermiculite)
MIL-V-21628	Vermiculite, Expanded (General Purpose)

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Noncombustible absorbent cushioning material, absorbent cushioning material, cushioning material, overpack material, hazardous liquids, packaging hazardous liquids.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This investigation was conducted at the request of HQ USAF. The objective of the investigation was to determine whether the quantity of noncombustible absorbent cushioning material used for overpacking unit containers of hazardous liquids can significantly be reduced from that presently specified in AFR 71-4, Preparation of Hazardous Materials for Military Air Shipment, by using plastic bags or liners inside the overpack containers. The plastic bag or liner would serve to confine liquids, in the event of leakage from unit containers, in overpack containers which are non-confining, such as fiberboard and unsealed

wooden boxes. Results of this investigation indicate that the quantity of cushioning materials presently specified in AFR 71-4 is probably based on that required to absorb the entire liquid content from leaking unit containers in non-confining overpack containers and can significantly be reduced by using overpack containers designed to confine liquids. For those overpack containers not so designed, closed plastic bags or liners offer an effective method to achieve confinement. The utility of plastic bags for this application will depend on the compatibility of plastics with a wide variety of hazardous materials.